MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVIII. *December* 13, 1867. No. 2.

Admiral R. H. MANNERS in the Chair.

The Earl of Rosse, Birr Castle, Ireland;
William Cotterell, Esq.. Walsal; and
David Gill, Esq., Aberdeen,

were balloted for and duly elected Fellows of the Society.

Note on the Total Solar Eclipse of 1868, *August* 17–18.

By G. B. Airy, Esq., Astronomer Royal.

It is perhaps deserving of notice that the path of the totally dark shadow in this great eclipse, between Africa and India, coincides through a large portion of its length with the courses of our mail-steamers between Aden and Bombay.

Under the new contract for the mail-conveyance (for early communication of the particulars of which I am indebted to the kindness of the Secretary of the Post Office), a mail-steamer is to leave Aden on August 16, and will be due at Bombay on August 23, and a mail-steamer is to leave Bombay on August 11, due at Aden (including the estimated effect of monsoon) on August 22. Both these steamers will pass through the dark shadow. The steamer from Bombay on August 18 will be starting nearly at the time of totality; but will not then be in the total darkness.

Although the motion of a ship destroys the possibility of making many of the most important of those observation which can be made on shore, yet various observations can be made well.

The red prominences which have been seen with the naked eye can certainly be seen with a good opera-glass, and their appearances and disappearances can be noted. The polarization of the corona can be seen well by a polarizing test which acts by extinction, as the Nicol's prism. Possibly, with a hand-spectroscope and narrow-chink, lines in the spectrum of the corona may be seen. And marine and meteorological phenomena may be noticed, such as have never yet been observed.

Viewing the general ability and intelligence of the Officers of the Peninsular and Oriental Steam Company, and the rank and education of the passengers who may probably be making the voyages, it is not too much to hope that advantage may be taken of this opportunity, such as will never again recur, to observe with care this great phenomenon.

Royal Observatory, Greenwich,
1867, *December* 7.

On the Solar Eclipse, Aug. 1868.

By G. Johnstone Stoney, M.A., F.R.S.

In May last I sent a Memoir to the Royal Society on the constitution of the atmospheres of the Sun and stars, which contained in an Appendix suggestions relative to observations of much interest which might be made during the Eclipse of August 1868, and for which there will not occur so good an opportunity for several years afterwards. An abstract of this communication has been published in the *Proceedings of the Royal Society*, and reprinted in the *Philosophical Magazine*, but the memoir and its appendix are not yet in type. As so great a delay has occurred, I fear lest the suggestions to which I have referred may not appear in time to be of use, and I therefore venture to submit them to the Royal Astronomical Society.

In the memoir it is shown that the gases which constitute the solar atmosphere range to unequal heights, and that the order in which the outer boundaries of those which are known succeed one another is probably the following:—Hydrogen extending furthest; then in order after it sodium and magnesium; calcium; chromium, manganese, iron, cobalt, and nickel; and lastly, copper, zinc, and barium. These, and whatever other gases exist in the Sun's atmosphere, intercept all light coming from beyond them of the refrangibilities which correspond to their spectral rays, and substitute for it the feebler light which emanates from their own upper strata. In this way they produce those dark lines in the spectrum which are so familiar, and the various intensities of which depend in great measure upon the different temperatures of the upper layers of the gases in which they have their origin.

Now if the Corona which is seen during a total eclipse is

caused, as we must presume, by the Sun's enormous outer atmosphere projecting beyond the disk of the Moon, the light which reaches us from it is probably in part borrowed light, and in part due to the atmosphere being itself self-luminous.* Borrowed light, however it may originate,* will give a spectrum resembling the Sun's, whereas any light emitted by the Solar atmosphere in virtue of its being incandescent will consist of bright rays in the same positions as some of Fraunhofer's lines. Accordingly, when examined through a spectroscope, adapted to an equatoreal telescope,† much of the light of the Corona may be found to resolve itself into a multitude of bright lines, the brightest being coincident with the faintest of Fraunhofer's lines. If this should prove to be the case, and if the observer could train himself to distinguish in the hurry and under such novel circumstance‡ the lines of the different gases, it would even be possible to ascertain how high in the Sun's atmosphere each reaches, by using a curved slit, and noting the moment at which each set of lines is obliterated by the advancing Moon. This would be a determination of exceeding interest. The observations should commence immediately after the beginning of totality and be kept up to the end of it, as it is only from situations close to the Sun's disk that the brightest lines can come.

Directly outside the photosphere there lies a stratum of the Sun's atmosphere which is still hotter than the photosphere, and on the outer boundary of this hot region there appears to be a shell of excessively faint cloud, part of which is to be seen in Mr. De La Rue's photographs of the Eclipse of 1860. It probably extends the whole way round the Sun. It is therefore very desirable that this faint shell, which seems to lie at a distance of 8 or 10 seconds of space from the edge of the Sun's disk, should be observed, both from a central station and from stations close to the northern and southern limits of totality, so as to ascertain whether, as we have reason to presume, it is continuous round the disk. For this purpose telescopes of moderate power, and any way mounted, would suffice.

It is not likely that there will be many spots, but if any should present themselves upon the edge of the disk within a week of the eclipse they should be observed for some days be-

* Borrowed light may come either from a mist of solid or liquid particles in the Sun's atmosphere, or because some of the gases are sensibly coloured, or from irregular refractions occasioned by the troubled condition of the Sun's atmosphere; but will not in any considerable degree arise from the illumination of the Earth's atmosphere. It is from the absence of this last and chief source of borrowed light that the Corona comes into view, and observations during an eclipse are so precious.

† The equatoreal stand is not essential, as it would be enough to provide a side reflector with a slit in it, through which the rays to be observed in the spectroscope shall pass; and the rest of the image being viewed in the reflector by an assistant, he could by hand movements sufficiently direct the telescope. A telescope of considerable aperture and focal length would be best.

‡ One of the most novel of these circumstances is that the spectrum of each gas will present itself with inverted intensity, the brightest lines obtained by artificial means being in general those which are dimmest in the Corona, and *vice versâ*.

fore and after, with a view to learning whether they are related to ascending clouds in the way pointed out in the memoir. These observations could probably be best made at Kew, but to guard against bad weather, it might be advisable to associate with Kew some other Observatory. Possibly there may be records in existence for instituting this inquiry in regard to the eclipses of 1842, 1851, or 1860. It is perhaps not impossible that the heavy mass of cloud marked $g\,g^1$ in Mr. De La Rue's diagram of the eclipse of 1860, may have been the source of a cyclone which occasioned the neighbouring group of spots. If so, the cloud must have afterwards drifted a good deal towards the pole (which is the direction in which the probable course of the solar trade wind would have carried it), and also come through the rotation of the Sun into a position in which it was much foreshortened.

Finally, it is evident from the observations of the eclipse of 1860, that flame-like protuberances are formed of various materials. Probably they are most of them very attenuated mists of solid or liquid particles, but it is also possible that there may be some in a gaseous state. It is, in fact, shown in the above-mentioned memoir that if two of the gases of the solar atmosphere are kept asunder by the temperatures which prevail in its low-lying strata, but can unite into a compound gas under the diminished temperature and pressure which prevail at greater heights, or *vice versâ*, the gas which in such cases presents itself only at great altitudes, will comport itself, in many respects, like a cloud, and in particular will become intensely heated, and emit the rays which constitute its gaseous spectrum. A similar state of things would result from such a change in the spectrum emitted by a constituent of the Sun's atmosphere, as we know from Plücker's experiments can take place in nitrogen and other gases. It is desirable, therefore, that the spectra of the protuberances should be examined, if this prove practicable, in order to determine whether they all resemble the solar spectrum, as they must if these clouds are all mists, or some of them consist of bright lines, as they will if gaseous. For such observations a telescope whose motions are under the control of an assistant looking in sideways would probably be best. I think, however, that the persons who are willing to devote themselves to such delicate observations would do well to prepare for them by staying for some time beforehand and up to the commencement of totality in the subdued light of a darkened chamber.

Shortly after the time of the solar eclipse the morning zodiacal light will be visible in great splendour to the members of the expedition, and it is very much to be desired that the opportunity should not be lost of obtaining a careful spectral examination of it by experts. This would not require any telescope;*

* That is, provided the collimator is sufficiently long to render the angular aperture of its lens viewed from the slit, not more than the angular breadth

but a binocular spectroscope, consisting of two similar instruments placed parallel to one another, would double the light.*

Some Remarks on the Value of the Solar Parallax, as deduced from the Parallactic Inequality in the Earth's Motion. By E. J. Stone, Esq.

In section 8 of Mr. Newcomb's "Investigation of the Distance of the Sun" will be found a discussion of the value of the Sun's mean equatoreal horizontal parallax given by the parallactic inequality in the theory of the Earth's motion. The coefficient of the parallactic inequality adopted by Mr. Newcomb is $6''{\cdot}520$, a value but little different from that adopted by Le Verrier in the *Annales de l'Observatoire Impérial de Paris*, Mémoires, tome iv., p. 100. The results obtained by Mons. Le Verrier were, if Π denote the mean horizontal equatoreal solar parallax, μ the mass of the Moon,

$$\mu = \frac{1}{81{\cdot}84} \quad \Pi = 8''{\cdot}95.$$

In the *Monthly Notices* for 1867, April 12, I pointed out, that a slight error had been made in the deductions of these values, and that the result should have been

$$\Pi = 8''{\cdot}91 \quad \mu = \frac{1}{81{\cdot}48}$$

Mr. Newcomb has obtained values widely different both from Mons. Le Verrier's original values and these values as corrected by me.

The values assigned by Mr. Newcomb are as follows:—

$$\Pi = 8''{\cdot}809 \quad \mu = \frac{1}{81{\cdot}08}$$

of the zodiacal light at the part of it observed. Otherwise, there will be advantage in placing a lens, which need not be achromatic, in front of each collimator.

* A similar arrangement might be used with a telescope upon all objects which are not stellar—the two spectroscopes being provided with collimators of unequal length and inclined to one another so as to be directed towards two parallel slits brought as close as possible together, and the light being diverted up one of the collimators either by total reflections, as in binocular microscopes, or by a small achromatised prism. In this way the light would be nearly doubled, an effect which could not be produced by an enlargement of the telescope. By moving the achromatised prism the image in one spectroscope could be made to shift laterally, and it is likely that the position of coincidence of the two spectra would be readily seized, even with extremely faint spectra. To secure this motion of the images with the instrument for observing the zodiacal light, the prisms of the spectroscopes might be placed a little out of the position of minimum deviation, and one of them so mounted as to admit of rotation through a small angle.

The discordances between the masses of the Moon and resulting parallaxes are so large that either Mr. Newcomb is in error or Mons. Le Verrier has made a much more important mistake than the trifling numerical one pointed out in my former paper.

I had examined Mons. Le Verrier's work by deducing a value of the Moon's mass before the publication of my short note in April, but I have now again gone through the work. The differences between the results obtained will be found to arise from two distinct causes.

1st, Le Verrier adopts

$$\text{Log } \frac{\Pi^3}{m''} = 8{\cdot}35199.$$

Newcomb adopts

$$\text{Log } \frac{\Pi^3}{m''} = 8{\cdot}35488.$$

2nd, Le Verrier finds for the relation between Π, μ and the adopted coefficient, the equation

$$\Pi = 0{\cdot}016620 \text{ P} \left(1 + \frac{1}{\mu}\right).$$

Newcomb,

$$\Pi = 0{\cdot}016461 \text{ P} \left(1 + \frac{1}{\mu}\right).$$

Neither Le Verrier nor Mr. Newcomb has given the data from which he has deduced his value of $\log \frac{\Pi^3}{m''}$.

I shall however assume the length of the invariable pendulum l beating a mean second on latitude $= \sin^{-1} \frac{1}{\sqrt{3}}$ to be

$$0^{m}{\cdot}992666 \frac{434{\cdot}86}{433{\cdot}86} \cdot = l \left(1 + \frac{2}{3} m\right)$$

and log (equatoreal semi-diameter of Earth in metres)

$$= 6{\cdot}8046271 = \log \text{R}$$

Logarithm, which must be added to log R to obtain the log (semi-diameter to the parallel $\sin^{-1} \frac{1}{\sqrt{3}}$) $= 9{\cdot}9995166$.

In these data I follow Hansen. The same data appear to me to have been adopted by Mr. Newcomb.

Then if

$$= c\left(1 + \left(\frac{1}{3} - \sin \lambda^2\right) \varepsilon\right)$$

be the equation of the Earth's spheroidal surface, fE the Earth's mass, m the ratio of $\frac{\omega^2 c}{\text{mean gravity}}$, we have

$$f\mathrm{E} = \mathrm{G}c^2\left(1 + \frac{2}{3}m\right),$$

where G is the gravity on parallel $\sin^{-1}\frac{1}{\sqrt{3}}$. Therefore

$$1 = \pi^2 \frac{l}{\mathrm{G}} = \pi^2 \frac{c^2 l}{f\mathrm{E}}\left(1 + \frac{2}{3}m\right). \qquad (1)$$

Now let T be the sidereal year expressed in mean seconds, a the length which satisfies Kepler's third law. Then

$$\mathrm{T}^2 = 4\pi^2 \frac{a^3}{f\mathrm{S}} \qquad (2)\quad \mathrm{S} = \left\{\begin{matrix}\text{Sun's mass}\\ +\text{ Earth's mass}\end{matrix}\right\}.$$

Now Le Verrier takes for his unit of length a, and he finds, expressed in this unit, r = mean distance of Sun from Earth $= 1{\cdot}000142 \times a$.

$$\therefore \qquad \mathrm{T}^2 = \frac{4\pi^2}{(1{\cdot}000142)^3 f\mathrm{S}} r^3 \qquad (3)$$

$$\therefore \qquad \frac{\mathrm{S}}{\mathrm{E}} \cdot \frac{c^3}{r^3} = \frac{4}{\mathrm{T}^2} \cdot \frac{1}{(1{\cdot}000142)^3} \frac{c}{l\left(1 + \frac{2}{3}m\right)}$$

Now $c = \mathrm{R}p$; where $\log p = 9{\cdot}9995166$.

$$\therefore \qquad \frac{\mathrm{S}}{\mathrm{E}} \cdot \frac{\mathrm{R}^3}{r^3} = \frac{4}{\mathrm{T}^2} \cdot \frac{\mathrm{R}}{l} \frac{1}{(1{\cdot}000142)^3 p^2\left(1 + \frac{2}{3}m\right)}$$

$$\frac{\mathrm{S}}{\mathrm{E}} \cdot \Pi^3 = \frac{4}{\mathrm{T}^2} \cdot \frac{\mathrm{R}}{l \sin^3 1''} \cdot \frac{1}{(1{\cdot}000142)^3 p^2\left(1 + \frac{2}{3}m\right)}$$

$$\mathrm{Log}\,\frac{\Pi^3}{m''} = 8{\cdot}35475$$

Agreeing closely with Mr. Newcomb's value.

From the theory of the motion of the Earth about its centre of gravity we have the following formula:— *Serret, Annales de l'Observatoire de Paris*, tome v.

$$(A) \qquad \varepsilon = \frac{\text{Mass of Moon}}{\text{Mass of Sun}} \left(\frac{\text{Mean Dist. of Sun}}{\text{Mean Dist. of Moon}}\right)^3$$

$$(1) \qquad N = [9{\cdot}38725]\ \varkappa\ \varepsilon$$

$$(2) \qquad P = [9{\cdot}96272]\ \varkappa + [9{\cdot}95922]\ \varkappa\ \varepsilon$$

$$N = 9''{\cdot}223 \qquad P = 50''{\cdot}378$$

I adopt the same values of the constants of nutation and luni-solar precession as Mr. Newcomb.

Then

$$\varepsilon = \mu\ \frac{E}{S} \cdot \left(\frac{\frac{R}{r_1}}{\frac{R}{r}}\right)^3$$

$$\varepsilon = \mu\ \frac{E}{S} \cdot \frac{(B \cdot \sin 1'')^3}{\Pi^3 \cdot (\sin 1'')^3} = \mu\ \frac{E}{S}\ \frac{B^3}{\Pi^3}$$

where B is the *constant* of lunar parallax.

$$\therefore \quad \varepsilon = \mu\ \frac{\frac{B^3}{\Pi^3}}{m''}$$

From (1) and (2) we find

$$\text{Log } \varkappa\ \varepsilon = 1{\cdot}57762$$

$$\text{Log } \varkappa = 1{\cdot}24018$$

$$\text{Log } \varepsilon = 0{\cdot}33744$$

$$\text{and} \qquad B = 3422''{\cdot}707$$

These data and the value of $\log \frac{\Pi^3}{m''}$ found in the present paper give $\mu = \frac{1}{81{\cdot}46}$. This value agrees closely with Le Verrier's value.

The expression for the lunar inequality in longitude is

$$\delta\theta = -\frac{m'}{m + m'}\ \frac{r'}{r}\ \cos s' \sin(\theta' - \theta)$$

where m and m' are the masses of the Earth and Moon respectively, r, r', the distances of the Sun and Moon from the Earth; s' the Moon's latitude; θ', θ, the true longitudes of the Moon and Earth. I shall assume that for r' the true value has been used by Le Verrier. Then, taking constant of lunar parallax $= 3422''{\cdot}7$, and denoting $\frac{m'}{m}$ by μ, the solar parallax by Π, I find

$$\Pi = 0{\cdot}016620\ P \left(1 + \frac{1}{\mu}\right)$$

a result agreeing with Le Verrier.

If we adopt Le Verrier's coefficient $6''{\cdot}50$, we find

$$\Pi = 8''{\cdot}91$$

I have not incorporated Mr. Newcomb's results with those of Le Verrier's, because Mr. Newcomb has employed the mean longitudes instead of the true. Taking Mr. Newcomb's results separately, we find for the coefficient the numerical value $= 6''{\cdot}548$. We must now use Mr. Newcomb's equation of condition between Π and P, but I use my own value of $\mu = \frac{1}{81{\cdot}46}$. I thus find

$$\Pi' = 8''{\cdot}89$$

a result almost identical with that obtained from Le Verrier's coefficient.

The values thus obtained depend, as I stated in my Note of April last, almost entirely on the adopted value of the Moon's mass. The deduction of the value of this quantity, to the required degree of accuracy, from the theory of Precession and Nutation. is a point of considerable difficulty. Mr. Newcomb has applied some corrections for terms of the third order to Serret's results for the equation determining the constant of Nutation, but has used the Precession equation unaltered. I have used Serret's results, neglecting all terms of the third order. If we employed Mr. Newcomb's value of the Moon's mass, we should find

$$\Pi = 8''{\cdot}87.$$

On Bessel's Mean Refractions. By E. J. Stone.

The refraction-corrections, employed in the reduction of the Greenwich Observations, since 1857, have been computed in the following manner:—

To 82° Z. D. the refractions are those of Bessel's *Tabulæ Regiomontanæ;* from 82° to 85° Z. D. those of the *Tabulæ Regiomontanæ,* with the logarithms of mean refraction diminished by 0·00100; and, finally, from 85° Z. D., the refractions are those of Bessel's *Fundamenta* diminished in the proportion of 1:0·99848. The abrupt changes in passing through 82° and 85° Z. D., can scarcely be considered satisfactory. From the existence of several small, but systematic discordances, I have for some time been convinced, that our refraction-corrections for zenith distances less than 85° are too great. The object of the present paper is to put this in evidence, and to endeavour to determine some more satisfactory method of computing the refraction-corrections.

I have, in the first place, compared the observations of stars above and below the pole, made at Greenwich from the years 1857 to 1865. Let c be the adopted co-latitude; $c + \frac{x}{2}$ the true co-latitude. R, R_1, the tabular refractions below and above the pole. $R(1-y)$, $R_1(1-y)$, the true refractions. Δs, Δd, the mean N.P.D. for the beginning of the year, derived from the observations below and above pole, respectively. a, b, the number of observations below and above pole. We then have an equation of condition

$$x + y(R \pm R_1) = \Delta s - \Delta d,$$

With a (probable error)^2 proportional to $\left(\frac{1}{a} + \frac{1}{b}\right)$.

From the observations of the different years I have found for each star the value of $\Delta s - \Delta d$ and have then weighted the several results, roughly, in proportion to $\frac{ab}{a+b}$ or w, and thus found mean values of $\Delta s - \Delta d$ with a weight $S(w)$. The factors for y are then computed for the star's zenith distance, with an assumed barometer reading of 30 in., and thermometer 50°. The results of each year have been thus separately treated, in order that the observations, above and below pole, might always have been corrected with the same empirical law of R — D, or law of discordance between reflexion and direct observations. A few observations are, of course, lost by this method of proceeding. I have thought this of little consequence compared with the probable diminution of systematic error. The reflexion observations having been used in determining the co-efficients in the assumed law of R — D have not been further employed in the present paper.

I have next divided the observations into five groups.

1st.	N.P.D.	0°	to 15°
2nd.		15°	to 30°
3rd.		30°	to 37° 40′
4th.		37° 40′	to 43°
5th.		43°	to 46° 29′

In the first group, *Polaris* is observed so frequently, that, if we weighted the observations merely in accordance with the number of observations, the co-latitudes would be made to depend almost entirely upon the observations of *Polaris*, and would thus be affected with any outstanding uncorrected error in the divisions of the circle employed in the observations of *Polaris* and *Polaris* S.P.

It became necessary, therefore, to fix upon some maximum for the weight, calculated in the ordinary way, from the number of observations. Let e be the probable error of an observation of

a star in N.P.D., determined in the ordinary way, by the discordances of the individual observations in a large group from the mean. ε the probable error of the outstanding division errors of the parts of the circle employed in the observations. Then if a, b, a_1, b_1, are the numbers of observations below and above pole of two different stars, and

$$w = \frac{a\,b}{a+b} \qquad\qquad w_1 = \frac{a_1 b_1}{a_1 + b_1}.$$

and W and W_1 are the true weights of the resulting co-latitudes. We have

$$\frac{1}{W} = \left(\frac{1}{a} + \frac{1}{b}\right) e^2 + 2\,\varepsilon^2 = \frac{e^2}{w} + 2\,\varepsilon^2,$$

$$\frac{1}{W_1} = \left(\frac{1}{a_1} + \frac{1}{b_1}\right) e^2 + 2\,\varepsilon^2 = \frac{e^2}{w_1} + 2\,\varepsilon^2,$$

$$\frac{W_1}{W} = \frac{1 + \frac{e^2}{\varepsilon^2} \cdot \frac{1}{2\,w}}{1 + \frac{e^2}{\varepsilon^2} \cdot \frac{1}{2\,w_1}}.$$

For *Polaris* and *Polaris* S.P. we have $e = 0''{\cdot}6$, and ε very nearly $0''{\cdot}2$. If, therefore, we put w indefinitely great

$$\frac{W_1}{W} = \frac{1}{1 + \frac{4{\cdot}5}{w_1}}$$

and for $w_1 = 20$,

$$\frac{W_1}{W} = \frac{5}{6} \text{ very nearly.}$$

After, therefore, the theoretical weight 20 is reached, very little greater accuracy can be expected, however much the number of observations may be increased.

I have employed 20 as the maximum weight to be assigned to the co-latitude determined from observations of any one star.

The discordances for the five groups are

(1)	$+\ 0''{\cdot}240$	weight	130
(2)	$+\ 0{\cdot}196$		88
(3)	$+\ 0{\cdot}570$		31
(4)	$+\ 1{\cdot}054$		54
(5)	$+\ 2{\cdot}190$		28

The equations connecting these discordances and the corrections for co-latitude and mean refraction are

$$
\begin{aligned}
(6) \quad & 11x + 1034y = + 2''.64 \\
(7) \quad & 9x + 1197y = + 1''.76 \\
(8) \quad & 6x + 1272y = + 3''.42 \\
(9) \quad & 7x + 2030y = + 7''.39 \\
(10) \quad & 5x + 2350y = + 10''.95
\end{aligned}
$$

The equations have been multiplied by numbers to make the probable errors of the second members nearly equal. Reducing these equations by the method of least squares, we find the following equations:

$$
\begin{aligned}
312x + 56465y &= 171''.88 \\
56465x + 13763349y &= 49920''.92
\end{aligned}
$$

From which we have

$$x = -0''.410 \qquad y = 0.00531$$

The discordances (1), (2), (3), (4), and (5), are reduced as follows:—

1	+ 0''.24	''.15
2	+ 0''.20	− 0''.10
3	+ 0''.57	− 0''.14
4	+ 1''.05	− 0''.08
5	+ 2''.19	+ 0''.10

The discordances are now reduced to quantities quite within outstanding division errors even over a group.

The result gives for Greenwich

co-latitude 38° 31′ 21″.61.

The value of y indicates that the mean refractions as given by Bessel's *Tabulæ Regiomontanæ* at barometer 30 in., and thermometer 50°, require to be diminished in the proportion of 0.99469: 1. I have here only considered the case of Z. D. from 0° to 85°.

Now in the *Tabulæ Regiomontanæ* the refractions to 85° Z. D. are those of the *Fundamenta* increased in the proportion of 1.003282 to 1.

If, therefore, we adopted the refractions of Bessel's *Fundamenta* we should only require to diminish the refractions in the proportion of 0.99797 to 1.

For zenith distances below 85° Z. D. the Greenwich Observations are at present reduced with the refractions of the *Fundamenta* diminished in the proportion of 0.99848: 1.

The refractions thus reduced appear to represent the observa-

tions as closely as can be well expected for such considerable zenith distances.

If, therefore, we adopted for Greenwich the refractions of the *Fundamenta*, with the mean refractions diminished in the proportion of

$$0{\cdot}99797 : 1,$$

we should have all our refractions computed from one set of tables, and representing the observations (in mean results) within, or at least very nearly within, errors of observation.

The publication of the Melbourne Observations for 1863, 1864, and 1865, furnishes a large number of observations in N.P.D. comparable with corresponding observations at Greenwich. I have, therefore, availed myself of the Melbourne Observations to test the accuracy of the proposed diminution of the Greenwich tabular refractions. It has, however, been first necessary to discuss the Melbourne Observations above and below pole in the same manner as the Greenwich Observations, in order to obtain the Melbourne colatitude. The Melbourne refractions have been computed from the *Tabulæ Regiomontanæ*. Proceeding exactly in the same way as for the Greenwich Observations, I have divided the results into five groups.

				Direct — S.P.	Weight.
(1)	N.P.D.	147°	to 150°	+2″·480	11
(2)		150	155	+1·585	8
(3)		155	160	+0·726	8
(4)		160	170	+0·738	26
(5)		170	Pole	+1·007	122

From these groups I have formed the following five equations with second members nearly equally probable:—

(6)	$3x$	$+1446y$	$= +7''{\cdot}440$
(7)	$3x$	$+1020y$	$= +4{\cdot}755$
(8)	$3x$	$+705y$	$= +2{\cdot}178$
(9)	$5x$	$+870y$	$= +3{\cdot}690$
(10)	$11x$	$+1694y$	$= +11{\cdot}077$

Solving these equations by the method of least squares, I find

$$x = +0''{\cdot}298 \quad . \quad y = 0{\cdot}00372$$

The discordances (1), (2), (3), (4), (5), are reduced as follows:—

1	+2″·48	to	+0″·39
2	+1·59		+0·03
3	+0·73		−0·44
4	+0·74		−0·20
5	+1·01		+0·23

There are many very abrupt changes in the corrections applied for division error to the Melbourne Circle, and some considerable uncertainty must exist from this cause in the results. I believe the above discordances are not much greater than may be expected.

Finally, I have compared the Greenwich and Melbourne Observations in N.P.D. I have employed for this purpose the results of the Greenwich seven-year Catalogue, and have brought up all the observations to the year 1864 for comparison with the Melbourne results. I have then divided the corresponding observations into eleven groups.

		Green. N.P.D. — Melb. N.P.D.	Weight.
1	N.P.D. 45° 12′	+ 3″·04	9
2	50° to 55°	+ 1·71	21
3	55 60	+ 0·87	25
4	60 70	+ 1·35	100
5	70 80	+ 1·52	121
6	80 90	+ 0·99	138
7	90 100	+ 0·62	82
8	100 110	+ 0·86	78
9	110 115	+ 0·83	53
10	115 120	+ 0·72	56
11	120°	+ 1·30	16

Assuming that the true refraction

For Greenwich = Tab. $(1 - x)$
For Melbourne = Tab. $(1 - y)$

and that the relative correction for errors in latitude is δc, we have the following equations with nearly equally probable second members:—

1	$21x$	$+1245y$	$= + 9''{\cdot}12$	$+ 3\,\delta c$
2	$65x$	$+1180y$	$= + 8{\cdot}55$	$+ 5\,\delta c$
3	$105x$	$+ 785y$	$= + 4{\cdot}35$	$+ 5\,\delta c$
4	$270x$	$+1200y$	$= +13{\cdot}50$	$+10\,\delta c$
5	$484x$	$+ 825y$	$= +16{\cdot}72$	$+11\,\delta c$
6	$720x$	$+ 660y$	$= +11{\cdot}88$	$+12\,\delta c$
7	$783x$	$+ 342y$	$= + 5{\cdot}58$	$+ 9\,\delta c$
8	$1260x$	$+ 207y$	$= + 7{\cdot}74$	$+ 9\,\delta c$
9	$1428x$	$+ 112y$	$= + 5{\cdot}81$	$+ 7\,\delta c$
10	$1995x$	$+ 77y$	$= + 5{\cdot}04$	$+ 7\,\delta c$
11	$1520x$	$+ 32y$	$= + 5{\cdot}20$	$+ 4\,\delta c$

From which we obtain the following equations for the determination of x and y:—

$$11371545\,x + 2274567\,y = 61872{\cdot}12 + 66005\,\delta c$$
$$2274567\,x + 6294185\,y = 67408{\cdot}69 + 48947\,\delta c$$

$$x = +0{\cdot}003556 + 0{\cdot}00458\,\delta c$$
$$y = +0{\cdot}009424 + 0{\cdot}00612\,\delta c$$

or putting $\delta c = -0{\cdot}056$,

$$x = +0{\cdot}0033$$
$$y = +0{\cdot}0091$$

The errors Green. N.P.D. — Melb. N.P.D. are then reduced as follows:—

			Weight.
(1)	$+3''{\cdot}04$ to	$-0''{\cdot}76$	9
(2)	$+1{\cdot}71$	$-0{\cdot}48$	21
(3)	$+0{\cdot}87$	$-0{\cdot}63$	25
(4)	$+1{\cdot}35$	$+0{\cdot}16$	100
(5)	$+1{\cdot}52$	$+0{\cdot}69$	121
(6)	$+0{\cdot}99$	$+0{\cdot}29$	138
(7)	$+0{\cdot}62$	$-0{\cdot}02$	82
(8)	$+0{\cdot}86$	$+0{\cdot}18$	78
(9)	$+0{\cdot}83$	$0{\cdot}00$	53
(10)	$+0{\cdot}72$	$-0{\cdot}33$	56
(11)	$+1{\cdot}30$	$-0{\cdot}04$	16

The first residual (1) depends upon the observations of only one star. If we rejected the equation arising from (1), the values of x and y would not be greatly modified. The discordances are here larger than could be wished, but, except for the first, I doubt whether they are greatly in excess of uncertainties connected with division errors.

The value of x shows that the refractions of Bessel's *Tabulæ Regiomontanæ* require to be diminished considerably in order to represent the Greenwich Observations. So far as the comparison with the Melbourne Observations is concerned, the refractions of the *Fundamenta* would almost do for Greenwich without any correction. I believe, however, that the result obtained from the Greenwich Observations, above and below pole, is entitled to most weight. The correction thus deduced for the Melbourne refractions is exceedingly great, viz. $y = 0{\cdot}00914$, whilst, from a comparison of the Melbourne Observations above and below pole, I obtained only a correction of

$$y = 0{\cdot}00372.$$

The discordance between these results is so great, that if we introduced one of the values into the equations from which the

other has been deduced, the residual errors would be much greater than any existing uncertainties connected either with observations or outstanding errors of division. At least this is my own opinion on the point. I am, therefore, inclined to look upon the difference as real, not perhaps to the full amount of the discordance, but to a considerable amount, and to attribute it to a real difference in mean refraction towards the south and north at Melbourne, the refractions towards the south being greater because of the moisture present in the air, the refractions towards the north being considerably less because the chief effective strata of air have been to a considerable extent deprived of moisture.

14th November, Meteor Epoch 1867. By E. J. Lowe, Esq.

Nov. 12. Foggy and densely overcast all evening and night.

Nov. 13. Foggy and overcast, with E.N.E. wind, till $7^h\ 40^m$ P.M., when the sky suddenly became cloudless and the wind changed to S.E, from this time till $9^h\ 10^m$ P M. no clouds and no meteors. At $9^h\ 10^m$ P.M. few cumuli; $9^h\ 30^m$ P.M. overcast with cumuli in S. current.

Nov. 14. $1^h\ 10^m$ A.M. again clear, except few high thin cirri. Wind S. Lunar halo faint, and a yellow glare on N. horizon extending to altitude 15°.

$1^h\ 27^m\ 30^s$ A.M. a colourless meteor, = ✱ 2 mag., shot rapidly from near λ to β *Ursæ Majoris.*

2 A.M. high thin cumuli in S., current moving rapidly.

2 A.M. till 3 A.M. ibid. No meteors.

$3^h\ 10^m$ A.M. sky covered with rapidly-flying thin cumuli in S.E. current, above which others in S. current. Slight breeze and no fog.

$3^h\ 55^m$ A.M. overcast, Moon's place visible.

$5^h\ 15^m$ A.M. ibid., wind N.E., clouds rapid from S.E.

$5^h\ 50^m$ A.M. quite overcast, hazy wind N.E.; sky lighter to E. of zenith than elsewhere.

$7^h\ 40^m$ A.M. ibid., fog coming on.

From 9 A.M. fog with incessant rain till 7 P.M., then fair; fog cleared off, but overcast.

15th. Overcast.

Highfield House,
1867, *Nov.* 19.

The Meteors of November 13–14, 1867, *observed at Bloomington, Indiana.* By Prof. Daniel Kirkwood, L.L.D.

During the night of November 13th, Prof T. A. Wylie, D.D., and myself, assisted by several students, kept watch for meteors from $9^h\ 15^m$ P.M. to $5^h\ 15^m$ A.M., at the Indiana University, Bloomington, Indiana. The night was very unfavourable for observations, the sky being obscured by so dense a haze that scarcely any fixed stars, except those of the first magnitude, were at all visible. Hence none but the largest meteors and such as appeared near the zenith could be detected. The results obtained were as follows:—

	h m	h m		
November 13th, from	9 15	to 12 0*	1	meteor.
14th,	0 0	3 15	75	meteors.
	3 15	4 15	351	,,
	4 15	5 15	98	,,
		Total	525	meteors.

It will be noticed that 351, or two-thirds of the whole number seen in eight hours, were observed between $3^h\ 15^m$ and $4^h\ 15^m$. The maximum occurred about $3^h\ 45^m$, when the rate was twelve per minute. All the meteors, with one or two exceptions, were "conformable." Two or three were sometimes seen simultaneously, and a tendency to appear in clusters was distinctly noticed. A very remarkable meteor was observed in *Leo*, a little above the *Sickle*, about $3^h\ 40^m$. It was *stationary*, and continued visible between two or three seconds. It was at first small, but increased rapidly in magnitude until, just before extinction, it surpassed *Regulus*, the only star in the *Sickle* then visible through the haze. This meteor was undoubtedly near the radiant. On account, however, of the cloudy state of the atmosphere no effort was made to locate the common point of divergence.

Bloomington, Indiana,
November 14th, 1867.

An Attempt to facilitate the Prediction of Occultations and Eclipses, and the Approximate Reduction of the observed Phenomenon. By F. C. Penrose, Esq. (Abstract.)

As regards occultations; an occultation (disappearance or reappearance) takes place when the surface of the Earth (considered in the memoir as a spheroid of revolution) intersects the cylinder generated by the rays of light proceeding from the star and touching the Moon's circumference.

* Cincinnati time.

The author submits two methods of solution, part of the process being in each of them geometrical, or, more properly speaking, graphical, conducted by means of an orthographic projection of the occurrence, as seen from the direction of the star: he thinks that the methods are capable of sufficient accuracy for many purposes, and have the advantage that the object of every step is readily seen by the operator, and also of being more expeditious than the methods depending solely on calculation.

The first method, worked with the help of Chart No. I., is intended for prediction only, and may be expected to occupy a few minutes only in the operation, and to furnish an approximate result with an error not exceeding two minutes of time in ordinary cases.

The second method worked by Chart No. II., and which depends to a less degree on geometrical work, ought to give a result true within two minutes of longitude, or eight seconds, or say half a second of the Moon's R.A., except in cases where the star impinges on the Moon's limb at an acute angle, or, in other words, when the observer is at a considerable distance from the central line of occultation, when the error will probably be greater; and such cases should not be relied upon for the determination of longitude unless both the disappearance and reappearance can be observed.

The representation of an eclipse, treated in an analogous way to the occultation, is that of a *perspective* projection on a plane perpendicular to the line of conjunction, and with the Sun at conjunction as the point of view, and at the Moon's distance from the Sun, instead of the *orthographic* projection which represented the occultation.

On the Influence of Aperture in Diminishing the Intensity of the Colour of Stars. By John Browning, Esq., F.R.A.S.

At the last Meeting of the Society some remarks were made on the subject of the amount of colour visible on the Moon during the late lunar eclipse.

I had previously stated that I had failed to detect either the coppery or the blue tints generally seen during the occurrence of this phenomenon. As my observation did not agree with those of several well-known observers, I have given the matter some attention, and endeavoured to ascertain from what cause the discrepancy proceeded.

Mr. Slack suggested that probably my having used a telescope of larger diameter than those employed by most of the observers would prove the explanation desired, and since then I have heard that our able Secretary, Mr. Huggins, is of the same opinion. The result of my inquiries completely confirms this suggestion. I find

that while most observers who use telescopes of only three or four inches aperture speak of the colour as being less than usual, yet very noticeable, observers who use telescopes of seven or eight inches aperture saw very little colour. Neither Mr. Barnes nor myself, observing with a $10\frac{1}{4}$-aperture, nor Mr. With or his nephew, employing a $12\frac{1}{4}$-inch silvered-glass speculum, could detect any colour at all.

It is true that I failed equally in detecting colour with a 4-inch object-glass, but I account for this by supposing that the sensitiveness of my eye to faint-coloured light had been injured by the glare of the Moon in the large aperture. Experimenting in connexion with this subject, I have noticed that the chocolate colour of the so-called belts of *Jupiter* is much more perceptible with 6-inches aperture than with 12-inches. Again, a small star in the cluster in *Perseus* appears of an indigo-blue with $8\frac{1}{2}$-inches, prussian-blue with $10\frac{1}{4}$-inches, and royal-blue with $12\frac{1}{4}$-inches of aperture. It follows from this that colours estimated by comparison with the ingenious chromatic scale of Admiral Smyth, in which each colour is represented of four different degrees of intensity, will not possess any relative value unless taken in connexion with the aperture employed when the colour was estimated. Were due allowance made for this disturbing influence of variation of aperture, I think many discrepancies between the colours attributed to double stars by different observers might probably be reconciled.

Note.—An enlarged diagram of Smyth's chromatic scale, and another showing the apparent difference in the colour of a star when seen with apertures of 4 inches and 12 inches, was exhibited and described at the time the paper was read.

Minor Planet (98).

The following elements, calculated by Herr Lehrmann from observations of Aug. 25, Oct. 2, and Nov. 4, are given *Astron. Nach.* No. 1669:—

Epoch, 1867, Oct. 2·0, Berlin M.T.

M	=	66° 47′ 48″·8	
π	=	276 39 54·8	Mean Equinox, 1867·0.
Ω	=	5 2 28·0	
i	=	8 35 34·9	
φ	=	7 39 29·5	
μ	=	776″·43667	
log a	=	0·439934	

ERRATUM IN LAST NOTICE.

Page 1, in the list of persons elected, *for* Alnwrah Road, *read* Almorah Road.

CONTENTS.

	Page
Fellows elected	17
Note on the Total Solar Eclipse of 1868, August 17–18, by Mr. Airy	ib.
On the Solar Eclipse, Aug. 1868, by Mr. Johnstone Stoney	18
Some remarks on the Value of the Solar Parallax, as deduced from the Parallactic Inequality in the Earth's Motion, by Mr. Stone ...	21
On Bessel's Mean Refractions, by Mr. Stone	25
14th November, Meteor Epoch 1867, by Mr. Lowe	32
The Meteors of November 13–14th, 1867, observed at Bloomington, Indiana, by Prof. Kirkwood	33
An attempt to facilitate the prediction of Occultations and Eclipses, and the approximate Reduction of the observed Phenomenon, by Mr. Penrose (Abstract)	ib.
On the Influence of Aperture in Diminishing the Intensity of the Colour of Stars, by Mr. Browning	34
Minor Planet (93)	35

Printed by STRANGEWAYS and WALDEN, Castle St. Leicester Sq. and Published at the Apartments of the Society, Jan. 9, 1868.